

REMARKS

By this response, claims 24 and 25 have been added, no claim has been amended, and claims 1-6, 8-15, 17, 18, and 23-25 remain pending. Claims 20-23 have been withdrawn from consideration by the Examiner in response to the telephone election of August 22, 2008. Reconsideration of the application is respectfully requested.

New claims 24 and 25 do not add new matter. The undesirable characteristics of exposing a dielectric to a powered plasma, for example dielectric film loss, is discussed in the last line of ¶[0015], for example. The anneal temperature and duration of claim 25 is discussed at ¶[0019], for example.

In the Office Action of August 28, 2008, the Examiner rejects claims 1, 8-15, and 18 under 35 USC §103(a) over Chang (US Pat. 5,643,407, hereinafter "Chang"), rejects claims 2, 5, 6, and 17 under 35 USC §103(a) over Chang in view of Sahbari (US 6,554,912, hereinafter "Sahbari"), rejects claim 3 under 35 USC §103(a) over Chang in view of Akino et al. (US Pat. 6,417,108, hereinafter "Akino"), and rejects claim 4 under 35 USC §103(a) over Chang in view of Akino, and further in view of Sahbari.

Interview Summary

The Applicants' representative would like to thank Examiners Golightly and Kornakov for granting and conducting an interview for the subject application on November 13, 2008. Discussion pertained generally to the application of Chang to claim 1. The Examiners agreed to further consider the arguments presented below.

Election/Restriction

On page 2 of the Office Action dated August 28, 2008, the Examiner required restriction under 35 USC § 121 between Group I, claims 1-6, 8-15, 17 and 18; Group II, claim 20 and Group III, claims 21-23. Applicants acknowledge the provisional election made by the undersigned on August 22, 2008 electing the invention of Group I, claims 1-6, 8-15, 17, and 18.

Rejections Under 35 USC §103(a)

With regard to the rejections under 35 USC §103(a), it is submitted that the examiner has not established a prima facie case of obviousness.

Claims 1, 8-15 and 18 are rejected under 35 USC §103(a) as being unpatentable over Chang.

Claim 1 recites a method for cleaning a wafer comprising, among other things: patterning a via or a trench, or both, in a porous, low-k dielectric layer overlying the wafer; cleaning a polymer residue from surfaces of the patterned dielectric layer using a wet clean solvent; performing a non-plasma anneal on the patterned dielectric layer to remove a component of the solvent prior to a metal deposition, wherein the anneal comprises a low pressure anneal from about one atmosphere of pressure to a substantial vacuum; and after an anneal duration of about six minutes or less, stopping the anneal.

Chang recites a method comprising etching a via opening through layers comprising spun-on glass 16 sandwiched between two silicon dioxide layers (14, 18). The patterning of the layers comprises the use of photoresist PR. Subsequent to the

etch, Chang removes the photoresist using a wet strip such as hydroxylamine. Next, Chang performs a "critical two-step spin-on-glass treatment process" comprising baking the wafer in a vacuum at a temperature of between about 250°C to 350°C for between about 20 to 40 minutes in a nitrogen ambient. The vacuum bake removes moisture from the exposed spin-on-glass layer within the via opening (col. 3, lines 13-37).

The Examiner acknowledges that Chang fails to disclose the anneal duration, but states that Chang discloses using hydroxylamine as a wet clean solvent prior to performing an anneal step. Chang teaches that the O₂ plasma ashing is optional (col. 3, lines 25-30).

The Examiner further states that because the O₂ plasma ashing is optional, "there is no O₂ plasma ashing decomposition of the alkyl in the organic spin-on-glass material to generate moisture (col. 3, lines 23-26) and, hence, such moisture is not a factor in the annealing duration. Rather, the hydroxylamine solvent is removed. It would have been obvious to one of ordinary skill at the time of the invention to remove the hydroxylamine solvent in the Chan[g] method in order to prepare the wafer for further processing, and to perform the anneal at a higher temperature than the boiling temperature of the component. Further, the annealing duration is a result-effective variable in that it is correlated with the removal of the solvent."

It is acknowledged that Chang states that "the O₂ plasma ashing is not critical to the process of the invention and need not be performed to achieve the desired prevention of poisoned via metallurgy" (col. 3, lines 27-30) and, as suggested by the Examiner, decomposition of the alkyl group by the O₂ plasma (col. 3, lines 22-24) would not be a source of moisture.

However, Chang also states that the moisture absorbed by the spin-on-glass layer can originate "from the atmosphere" (col. 1, lines 38-41 and col. 3, line 40-42) as well as from decomposition of the alkyl group during the O₂ plasma. While decomposition of the alkyl group from the O₂ plasma may not be the source of the moisture, the goal of Chang is still to remove moisture from the spun-on glass regardless of the source.

Thus the Examiner statement that "moisture is not a factor in the annealing duration" is respectfully traversed. The purpose of Chang is to remove moisture regardless of the source, and thus the "critical" baking step is performed for a duration of "about 20 to 40 minutes."

There is no teaching, suggestion, or motivation within Chang to stop the baking process "after an anneal duration of about six minutes or less," at least because Chang describes the 20-40 minute baking step as "critical" and the baking step is performed to remove moisture from the spun-on glass layer. The rejection of claim 1 over the teachings of Chang requires the use of the Applicants' own claims as a blueprint, which is impermissible (*Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1143 (1985)).

The Examiner also states that the "annealing duration is a results-effective variable that is correlated with the removal of the solvent." Chang's process is performed to remove moisture, which can be absorbed into the spin-on-glass layer. Chang states that this moisture can be released after forming the metal layer within the opening in the dielectric to diffuse to the interface between the first and second metal layers and causing "poisoned via metallurgy" (col. 1, lines 40-46). Chang performs the anneal to remove this moisture. In contrast, the claimed process is performed to

"remove a component of the [wet clean] solvent" which can result in failure due to "high levels of organic material" (¶¶0015). Further, it was "initially assumed that the resist removal had not been complete," but the actual cause was discovered by the inventors as detailed in ¶¶0015]-[0017]. Thus optimizing the anneal duration for the process of Chang to remove moisture would not result in optimization of the process for the claimed process to remove "a component of the solvent." Thus it is submitted that the processes are clearly different, and claim 1 is allowable over Chang for at least this reason.

It is well established that excessive heat is detrimental to semiconductor structures during processing and that process engineers attempt to minimize the exposure of the semiconductor wafer to heat to remain within a "thermal budget." Chang recites performing the baking step for 20 to 40 minutes, and thus it appears that about 20 minutes would be a minimum baking time to practice the method of Chang. To conserve the thermal budget, Chang would have minimized the baking step duration, and thus it is submitted that the anneal time currently claimed is novel and nonobvious over the method of Chang.

It is therefore that rejected claims 1, 8-15, and 18 are allowable over Chang for at least these reasons. Reconsideration and withdrawal of the rejections are respectfully requested.

Claims 2, 5, 6, and 17 have been rejected under 35 USC §103(a) as being unpatentable over Chang in view of Sahbari.

Sahbari has been cited for its recitation of using specific materials as dielectric layers, and lists, for example, siloxanes, silicon dioxides, silsesquioxanes such as

methyl silsesquioxane (col. 7, lines 46-51), for its disclosure of hard baking and autoplasmashing (col. 8, lines 58-60), for its disclosure of ashing a photoresist by oxygen plasma (col. 12, line 67), and for its disclosure of copper deposition (col. 8, lines 48-52).

Because a hypothetical combination of references, if possible, would be concerned with the removal of moisture from the cited materials for the reasons discussed relative to the rejection of claim 1 over Chang, the rejected claims which depend from claim 1, which recites "performing a non-plasma anneal on the patterned dielectric layer to remove a component of the solvent" and "after an anneal duration of about six minutes or less, stopping the anneal" are allowable over cited references.

Thus it is submitted that rejected claims 2, 5, 6, and 17 are allowable over Chang and Sahbari in combination. Reconsideration and withdrawal of the rejections are respectfully requested.

Claim 3 has been rejected under 35 USC §103(a) as being unpatentable over Chang in view of Akino. Claim 3, which depends from claim 1, recites "cleaning a polymer residue from surfaces of the patterned dielectric layer using a wet clean solvent, wherein the wet clean solvent comprises an acid."

At the location cited by the Examiner, Akino teaches the use of hydrofluoric acid to etch an insulation film such as silicon oxide (col. 6, lines 30 and 31) and not to clean "a polymer residue from surfaces of the patterned dielectric layer" as presently claimed. Thus claim 3 is further allowable over the combination of references as applied by the Examiner. Note, however, the present specification at ¶[0004] which recites that

“standard post-etch clean procedures use a dry (plasma) clean to strip the photoresist followed by a wet (solvent or acid-based) clean to remove post-strip polymer residues.”

Claim 4 is rejected under 35 USC §103(a) as being unpatentable over Chang in view of Akino and in further view of Sahbari. Akino has been cited for its recitation of hydrofluoric acid, and Sahbari has been cited for its recitation of DMAC.

As discussed above relative to the rejection of claim 1 over Chang, a hypothetical combination of the cited references would necessarily be concerned with moisture removal. Thus claim 4, which recites “performing a non-plasma anneal on the patterned dielectric layer to remove a component of the solvent... and, after an anneal duration of about six minutes or less, stopping the anneal” is novel and nonobvious over the combination of references. Chang performs the anneal to remove moisture, not to remove a component of the solvent as claimed. Further, to remove the moisture, Chang performs the “critical” step for a duration of about 20 to 40 minutes, not “six minutes or less” as recited in claim 1.

For at least the foregoing reasons, the rejected claims are allowable over the cited references. Reconsideration and withdrawal of the rejections are respectfully requested. Any claim not individually addressed is allowable at least by virtue of its dependency from an allowable base claim.

New Claims

New claims 24 and 25 are allowable over the cited references. Claim 24 recites the deposition of a metal layer, wherein the patterned trench or via, or both, is not subjected to a powered plasma before depositing the metal layer. Chang, for example, as part of the "critical" process, uses a plasma powered at 180 to 220 watts to convert the organic material to an inorganic material (col. 3, lines 30-48). Claim 25 recites an anneal duration of about 250°C for a duration of about 45 seconds, while the process of Chang requires a temperature of between 250°C and 350°C for a duration of about 20 to 40 minutes (col. 3, lines 30-36).

Conclusion

In view of the foregoing amendments and remarks, Applicant respectfully requests reconsideration and reexamination of this application and the timely allowance of the pending claims. This is believed to be a complete and proper response to the Examiner's Office Action.

If the Examiner believes that additional discussions or information might advance prosecution of the application, the Examiner is invited to contact the undersigned at the telephone number listed below to expedite resolution of any outstanding issues.

Please grant any extensions of time required to enter this response and charge any additional required fees to Texas Instruments' deposit account no. 20-0668.

Respectfully submitted,

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